UV/Optical Nuclear Activity in the gE Galaxy NGC 1399

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ABSTRACT

Using HST/STIS, we have detected far-ultraviolet nuclear activity in the giant elliptical galaxy NGC 1399, the central and brightest galaxy in the Fornax I cluster. The source reached a maximum observed far-UV luminosity of $\sim 1.2 \times 10^{39}$ ergs s^{-1} in January 1999. It was detectable in earlier HST archival images in 1996 (B band) but not in 1991 (V band) or 1993 (UV). It faded by a factor of $\sim 4\times$ by mid-2000. The source is almost certainly associated with the low luminosity AGN responsible for the radio emission in NGC 1399. The properties of the outburst are remarkably similar to the UV-bright nuclear transient discovered earlier in NGC 4552 by Renzini et al. (1995). The source is much fainter than expected from its Bondi accretion rate (estimated from *Chandra* high resolution X-ray images), even in the context of "radiatively inefficient accretion flow" models, and its variability also appears inconsistent with such models. High spatial resolution UV monitoring is a valuable means to study activity in nearby LLAGNs.

Subject headings: galaxies: elliptical — ultraviolet: galaxies — galaxies: active

1. Introduction

There is now convincing kinematic evidence that most large elliptical and spiral galaxies contain supermassive nuclear black holes (SMBHs) with masses proportional to the masses of their spheroidal components (e.g. Magorrian et al. 1998, Ferrarese & Merritt 2000, Gebhardt

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et al. 2000; and reviews by Kormendy & Richstone 1995 and Ho 1998). Only a small fraction of these exhibit the prodigious central energy releases traditionally associated with active galactic nuclei. Instead, most are "low-luminosity active galactic nuclei" (LLAGN's), with bolometric luminosities less than 1% of their Eddington luminosities (e.g. Ho 2003).

In principle, the shape and variability of the multiband electromagnetic spectrum (radio through X-ray) of LLAGNs contains a great deal of information about energy conversion mechanisms in the vicinity of the SMBH and the processes which feed the activity (see §4). Only recently, however, have observational facilities improved to the point that LLAGN can be explored at levels below $L \sim 10^{40}$ ergs s^{-1} at UV/optical wavelengths in nearby galaxies. With small aperture spectroscopy, Ho and his colleagues find signatures of nuclear activity in the form of optical emission lines (e.g. LINERS) in about half of all nearby galaxies (Ho, Filippenko & Sargent 1997). There are remarkably large ranges in the shape of the LLAGN spectra and in their luminosity relative to the estimated SMBH mass (Ho 2002). The faintest LLAGNs in the emission-line samples have $\lambda L_\lambda \sim 10^{38-39}$ ergs s^{-1} at optical wavelengths.

In addition to their importance in spectral shape tests of AGN mechanisms, vacuum ultraviolet ($\lambda \sim$ 1100-3000 Å) observations with the *Hubble* Space Telescope (HST) can push down the detection threshold for LLAGNs for two reasons. First, the high spatial resolution of the HST (with a point-spread-function area $\sim 200\times$ smaller than at ground-based observatories) allows better isolation of faint point sources in the galaxy cores. Second, the flux contrast between the flat energy distribution of an AGN and the steep spectral background of a typical galaxy core with an older stellar population dramatically improves in the UV, by factors up to $100\times$ over that in the V-band (e.g. O'Connell 1999). HST surveys (Maoz et al. 1995, Barth et al. 1998) for UV-bright nuclear sources show nuclear peaks in excess of the interpolated stellar background in about 15% of the cases, but not all of these are AGN's. Some are clearly young star clusters or other extended sources (e.g. NGC 2681, Cappellari et al. 2001). Source variability is an important means of distinguishing true AGN's from these other phenomena.

One of the most intriguing instances of unusual LLAGN activity was the serendipitous discovery by Renzini et al. (1995) of a transient UV point source in the center of the Virgo Cluster giant elliptical NGC 4552 on UV exposures with the HST/Faint Object Camera. The source was detected at three epochs (1991, 1993, and 1997), during which it brightened by a factor of $4.5\times$, then faded. Although NGC 4552 was known to host a variable compact radio source (e.g. Wrobel & Heeschen 1984), there had been no earlier evidence for activity in the UV/optical bands, and the galaxy had not been classified as a LINER. Spectroscopy by Cappellari et al. (1999) showed that the source was indeed a faint LINER/Seyfert nucleus with a broad Hα emission line luminosity of $\sim 5.6 \times 10^{37}$ ergs s^{-1}. The outburst's UV

luminosity was $\lambda L_\lambda(\mathrm{UV}) \sim 7.5 \times 10^{38}$ ergs s^{-1}, and its estimated bolometric luminosity was $L_{\mathrm{bol}} \sim 3 \times 10^5\,\mathrm{L}_\odot$, comparable to the faintest optical-band detections. ROSAT detected a compact nuclear X-ray source in NGC 4552 with a luminosity of $L_{\mathrm{X}} \sim 5 \times 10^{40}$ ergs s^{-1} (Brown & Bregman 1998; Beuing et al. 1998; Schlegel, Petre, & Loewenstein 1998). Nuclear UV variability has also been detected in the LINER nucleus of the Sb galaxy NGC 4579 (Barth et al. 1996) and in the well-known AGN and jet of the gE galaxy M87 (Perlman et al. 2003).

In this paper we report the discovery on a spectrum taken with the *Hubble* Space Telescope Imaging Spectrograph (STIS) of a UV-bright active nucleus in NGC 1399, another outwardly normal gE galaxy. NGC 1399 is the central and brightest ($M_{\mathrm{B}} = -21.3$) object in the Fornax I cluster of galaxies. It hosts a small cluster X-ray bright cooling flow with a formal mass deposition rate of $\sim 2\,\mathrm{M}_\odot$ yr^{-1} (Rangarajan et al. 1995). Extensive studies have been made of its large globular cluster system (e.g. Dirsch et al. 2003 and references therein). Unlike M87 in the Virgo Cluster, which it otherwise resembles, NGC 1399 had exhibited only modest signs of nuclear activity, in the form of a weak radio source. It is not classified as a LINER. Its radio and X-ray properties are discussed further in §4. We adopt a distance of 20.3 Mpc for the Fornax cluster based on surface brightness fluctuation measurements by Jerjen (2003).

We describe our HST spectroscopy in §2. In §3 we combine that with a reanalysis of other HST observations taken from the HST archive to describe the properties of the nuclear point source. In §4 and §5 we interpret the results in the context of other data on NGC 1399 and recent models for nuclear activity.

2. Spectroscopic Observations

We observed the center of NGC 1399 with the HST/STIS and the Far-UV MAMA detector on 19 January 1999 as part of HST GO Program 7438. We used the low-resolution G140L grating, which covers 1150-1700 Å. Because we were interested in determining the spectrum of the diffuse UV stellar radiation in the galaxy, we used a 2″ wide slit, which is not well suited for detection of point sources. This yields a mean effective spectral resolution of only 48 Å but provides full STIS resolution (pixel size 0.024″or 2.4 pc) in the spatial direction. The slit was oriented in PA 30°. It was centered on the nucleus and extended ±12″ from the nucleus. The total exposure time was 11239 sec, broken into four exposures.

A week earlier (10 January 1999) we had also obtained a complementary optical-band spectrum (5402 sec exposure) with the STIS/CCD detector in the same slit position but

with a narrower 0.2″ wide slit. The spatial scale per pixel is 0.051″. With grating G430L, the spectrum covers 2900-5650 Å at a resolution of 2.7 Å per pixel.

The exposures in each camera were reduced with the standard STIS pipeline of the Space Telescope Data Analysis System and co-added together to produce two 2-dimensional images in (wavelength, radius) coordinates. We applied a time-dependent correction for dark count background, but otherwise reduction of the FUV data was routine. However, the optical-band spectrum required special treatment for removal of numerous cosmic rays.

3. Results: A Nuclear Point Source

NGC 1399 was already known to be unusually bright for an elliptical galaxy in the far-ultraviolet. It has the highest ratio of FUV to V-band light (i.e. the strongest "UV-upturn" component) among nearby gE's (Burstein et al. 1988) and has an exceptionally high central UV surface brightness, with an average $\mu_\lambda(1500\,\text{Å}) \sim 19.2$ mag arcsec^{-2}, within $r = 3''$ (O'Connell et al. 1992). This light is produced predominantly by hot "extreme horizontal branch" stars in the normal old stellar population of gE galaxies (O'Connell 1999 and references therein). Brown et al. (2002) used the Far Ultraviolet Spectroscopic Explorer to measure stellar absorption lines in the 900-1200 Å region of the hot component; they obtained abundances for N, Si, and C consistent with the expected overall high metallic abundances in a gE galaxy coupled with gravitational diffusion in the hot stellar atmospheres.

A spatial profile of our STIS FUV spectral image covering the range 1340-1710 Å (which avoids the strong airglow lines at shorter wavelengths) is shown in Figure 1. The plot shows the expected, smoothly extended UV continuum profile. But there is a distinct, pointlike source at the core of the profile. The source lies within $\sim 0.04''$ (4 pc) of the photometric center of the galaxy as defined by the symmetry of the background UV stellar light. Because NGC 1399 has the broad core-like central light profile characteristic of luminous E galaxies, this source is not related to the (stellar) light spikes found in lower luminosity galaxies with power law profiles (Stiavelli, Moller, & Zeilinger 1993; Lauer et al. 1995; Faber et al. 1997).

We used the profile shown in the figure to estimate the mean flux of the point source in the 1340-1710 Å band. The source is low contrast and superposed on the bright galaxy core, which has a strong radial brightness gradient. We measured the excess flux over the estimated background within a ± 2.5 pixel region centered on the source. We then extrapolated to total flux using the known point source encircled energy function for the spectrograph, as given in the STScI *STIS Instrument Handbook*. The main uncertainty in this and the other measurements reported here arises from the interpolation of the background light to the

nuclear position. Error bars were estimated from interpolations using maximum or minimum slopes for the background light profile.

We find that the nuclear source has a mean flux density $f_\lambda \sim 1.6 \pm 0.4 \times 10^{-17}$ erg s^{-1} cm^{-2} Å^{-1} in the 1340-1710 Å band, or $m_\lambda(1525\,\text{Å}) = 20.9$ in the STMAG monochromatic system ($m_\lambda = -2.5 \log f_\lambda - 21.1$, where f_λ is in units of ergs s^{-1} cm^{-2} Å^{-1}; Holtzman et al. 1995). The energy distribution of the source is roughly flat in f_λ units over the FUV band, and no emission or absorption features are apparent (though such would be heavily smoothed by the wide effective bandwidth).

The point source is also detectable in our optical-band STIS/CCD spectrum, though with lower contrast. It shows a smooth continuum, without emission lines and also without the strong absorption lines characteristic of the cool stars in the galaxy background light. We made an extraction of the 2-D spectral image corresponding to the coverage of the WFPC2 F450W filter (3950-4870 Å) and, using the method described above, measured the mean flux density of the nuclear source to be $f_\lambda \sim 6.4 \pm 1.3 \times 10^{-18}$ erg s^{-1} cm^{-2} Å^{-1} in this band.

Our optical spectrum does not extend completely through the regions covered by the F555W or F606W broad-band imaging filters on the HST cameras. However, to provide a rough comparison, we extracted a mean flux density for the nuclear source in the 400 Å region centered on 5430 Å of $f_\lambda \sim 6.7 \pm 2.2 \times 10^{-18}$ erg s^{-1} cm^{-2} Å^{-1}.

There are long-exposure images of the center of NGC 1399 at four other epochs in the HST archives. Two of these have been discussed in the literature. Renzini et al. (1995) and Cappellari et al. (1999) had scrutinized the 5 October 1993 FOC/UV image of NGC 1399 and found a perfectly smooth light distribution. There was no point source present comparable to the one they detected on similar FOC/UV imaging in NGC 4552. Likewise, Stiavelli et al. (1993) analyzed the 7 November 1991 WFPC1/PC image of NGC 1399 in the V band, comparing it to high resolution, ground-based R band images. Although the central pixel of the HST image showed a small excess, there was no evidence for the expected wings of the point-spread function (PSF) at larger radii. They found distributed light in excess of an isothermal core on both image sets, but this did not correspond in structure to that expected from a point source. Lauer et al. (1995) analyzed the same WFPC1/PC image as Stiavelli et al. (1993) and again found no evidence for a nuclear point source. Note that although both the 1991 and 1993 HST observations were made with the aberrated HST optics, which produced large image wings, the core of the aberrated PSF is quite sharp (FWHM $\sim 0.04''$) and would permit detection of a nuclear point source.

None of these earlier studies provided quantitative limits on the flux from a nuclear point source, so we re-analyzed the archival images. That included two additional WFPC2

observations made with the PC chip in 1996 and 2000 (with full correction for the spherical aberration). NGC 1399 has nearly circular isophotes, so we performed photometry on the images with circular or annular apertures centered on the point of light symmetry. We interpolated the background surface brightness to the nuclear position and measured the excess light in a central aperture of between 2 and 5 pixel radius, depending on the image. We then extrapolated to total flux using the known encircled energy functions for each camera and filter as given in the STScI handbooks. Again, the dominant source of photometric error in this process is the interpolation of the bright stellar background light to the galaxy center; error bars or limits were estimated as previously described. Results of the photometry are given in Table 1 as detections or 3σ upper limits.

Apart from the 1999 STIS observations, only in the case of the 2 June 1996 WFPC2 F450W image do we detect a point source. A plot of the central light profile from that image is shown in Figure 2. The signature of a point source is clear, although its effects are confined to the innermost 5 pixels ($r \lesssim 0.06''$).

In 1999, the UV/optical color of the source was $m_\lambda(1525\,\text{Å}) - m_\lambda(4480\,\text{Å}) \sim -1.0$, corresponding to the energy distribution of a late B star or a power-law index of $\alpha \sim 1.2$, where $f_\nu \sim \nu^{-\alpha}$. This is a softer spectrum than is typical of AGN but is within the rather large dispersion observed in AGN continua (e.g. Risaliti & Elvis 2004). The extracted UV and optical spectra of the source are each consistent, within the appreciable noise, with the modest spectral slope ($f_\lambda \sim \lambda^{-0.8}$) implied by this index.

We do not believe extinction by dust has much effect on these measurements at either optical or UV wavelengths. Foreground Galactic extinction is negligible, and no evidence of UV extinction was detected on the spatial scales ($\sim$ 3-60$''$) accessible to the Ultraviolet Imaging Telescope or the spectra from the Hopkins Ultraviolet Telescope (Ferguson et al. 1991; O'Connell et al. 1992; O'Neil et al. 1996; Ohl et al. 1998; Marcum et al. 2001). Our STIS spectrum has a smooth, symmetrical spatial profile, with no evidence of the dusty lanes or disks found in some E galaxies.

4. The Variable AGN in NGC 1399

In the last column of Table 1 we have converted the monochromatic flux densities or limits to luminosities per decade (λL_λ) for easier multiband comparisons. This is a heterogeneous collection of measurements in different bands. However, because of its flat energy distribution ($\lambda L_\lambda \sim \lambda^{0.2}$), if the nuclear source were non-variable we would have obtained approximately the same numerical values at all epochs in all of the optical bands.

The table provides good evidence that the source varied by a factor of $\gtrsim 3$ in brightness at both UV and optical wavelengths over the period 1991-2000. We cannot determine the duty cycle of the source or decide if the activity is part of a continuing flickering or is an unusually large, flare-like outburst. If only a single event was involved, it began by mid-1996. Brightest values were measured in 1999, and it appears to have faded by $\sim 4\times$ in the 16 months between January 1999 and May 2000.

Normal stellar phenomena in old stellar populations are too faint to produce this kind of nuclear source (cf. Renzini et al. 1995). The absolute monochromatic magnitude of the source in 1999 was $M_\lambda(1525\,\text{Å}) \sim -10.6$. The brightest known globular clusters in our Galaxy and in the gE galaxy M87, for instance, are fainter than this, at -8.9 and -9.6 respectively, in the far-UV (Sohn et al. 2004). The integrated light of clusters also, of course, cannot change more than that of the variable stars within them. The temporal behavior of the source is not consistent with a supernova. Novae and other UV transient sources have been detected in long-term HST monitoring programs of M87 directed by J. Biretta and W. Sparks (e.g. Sparks et al. 2000) and in a shorter program by Shara et al. (2004) and Baltz et al. (2004). However, these are again considerably fainter than the NGC 1399 nuclear source. For instance, 11 novae in M87 were identified by Sohn et al. (2004), but they are all fainter than $M_\lambda(2500\,\text{Å}) = -7$. Most nova outbursts also do not persist for more than about 6 months, so multiple events would be required to explain the observations. Several kinds of hot massive stars (e.g. O3-O7 dwarfs, OB supergiants, and Wolf-Rayet stars) have $m_\lambda(UV) - m_\lambda(V) \lesssim -4.0$ and can be both as bright as the nuclear source and also exhibit variability. However, there is no other evidence for a very young stellar population in NGC 1399. Finally, the exact coincidence of the source with the nucleus of NGC 1399 together with the absence of comparable extra-nuclear sources on any of the available data sets argues against a normal stellar phenomenon.

The only earlier evidence of nuclear activity in NGC 1399 was a low-luminosity central radio source (Killeen, Bicknell & Ekers 1988; Sadler, Jenkins & Kotanyi 1989). This consists of a core and two oppositely-directed jets feeding diffuse lobes. The whole structure is small and lies entirely within the optical body of the galaxy. Corrected to our adopted distance for NGC 1399, the total radio luminosity is 2.2×10^{39} ergs s^{-1}, while the luminosity in the unresolved core is only 6.6×10^{37} ergs s^{-1}.

X-ray observations with ROSAT and the *Chandra* X-Ray Observatory have placed only upper limits on the X-ray luminosity of NGC 1399's nucleus (Sulkanen & Bregman 2001; Loewenstein et al. 2001). The *Chandra* limit is $L_{\rm X} < 9.7 \times 10^{38}$ ergs s^{-1} in the 2-10 keV band (data taken on 18 January 2000). There are, however, over 200 extra-nuclear X-ray point sources detected, many associated with globular clusters (Angelini, Loewenstein

& Mushotzky 2001). These are presumably low-mass X-ray binaries. There are, in fact, so many of them that they interfere with obtaining better limits on the nuclear X-ray brightness.

The UV/optical nuclear point source we have found is almost certainly the AGN responsible for the radio emission in NGC 1399. Its luminosity at detection was $\lambda L_\lambda(\mathrm{UV}) \sim 1.2 \times 10^{39}$ ergs s^{-1}.

The activity in NGC 1399 is nearly identical in photometric properties to the UV nuclear transient in NGC 4552 (Cappellari et al. 1999). Given the fact that UV observations of E galaxies with HST have been made only infrequently, the accidental discovery of two such episodes in 6 years implies that high resolution UV monitoring is a productive means of isolating nuclear activity in nearby galaxies.

5. Discussion

The radio, optical, and UV data discussed above demonstrate that NGC 1399 contains a variable AGN, but it is definitely an inconspicuous one and falls in the LLAGN category. Because of NGC 1399's proximity, one can explore accretion of interstellar or intracluster gas by the nucleus in ways not possible for more distant sources. Loewenstein et al. (2001) have used a kinematic estimate of the mass of the central SMBH from Merrit & Ferrarese (2001) together with the high resolution *Chandra* X-ray images to estimate that the Bondi accretion rate onto the SMBH from the surrounding diffuse, hot medium is $\sim 0.04\,\mathrm{M}_\odot$ yr^{-1}. The predicted bolometric luminosity, assuming the standard 10% efficiency for conversion of accreted material to photons, is then $\sim 2 \times 10^{44}$ ergs s^{-1}. But this is a factor of 10^5 greater than the observed luminosity of the nuclear source in any of the bands described above.

This gross radiative inefficiency compared to the expectations of simple inflow models is characteristic of LLAGNs. It is possible that the gas inflow rates have been seriously overestimated, and it is usually difficult to obtain good observational constraints on the flows at the necessary spatial scales. More frequently, however, it has been argued that the nuclear structure of LLAGNs may differ fundamentally from those of more active systems, which are dominated by optically thick accretion disks. At very sub-Eddington accretion rates, the structure of the gas flow near a SMBH may change in such a way that little of the dissipation energy generated by the inflow appears as electromagnetic radiation, instead being advected across the event horizon or expelled in a wind or jet. The resulting efficiency of mass conversion to luminosity would be much below the 10% typical of luminous AGN's. Such structures are called RIAFs for "radiatively inefficient accretion flows" (e.g. Quataert 2003), and there are several possible types of them (e.g. Narayan & Yi 1994, Fabian & Rees

1995, Blandford & Begelman 1999, Quataert & Gruzinov 2000, Hawley & Balbus 2002, and references therein), featuring a variety of components such as spherical inflows, hot coronas, inner tori, optically thin Keplerian disks, convection currents, and jets or other outflows.

A basic expectation of RIAF models, confirmed by numerical simulations (Hawley & Balbus 2002), is that the flow structure can be strongly time-dependent and should respond sensitively to changes in the overall mass accretion rate. The resulting variations in the broad-band spectrum are observable. The source luminosity relative to the accretion rate, the shape of the energy distribution, and the variability with photon energy are key tests of the viability of the various RIAF models (Quataert & Narayan 1999, Ho 2002, DiMateo et al. 2003).

Vacuum-UV observations are important constraints on the models. In conventional dense accretion disk models, strong thermal continuum emission from the inner disk generates a "big blue bump" at UV wavelengths. This can lie at the peak of the λL_λ energy distribution, and both X-ray and UV emission can vary rapidly because of the small size of the emitting volume (e.g. Ptak et al. 1998). By contrast, RIAFs are thought to lack such dense disks at small radii, and most models predict that emission will be suppressed in the UV compared to the radio and X-ray regions. UV photons are produced over a large range of radii ranging up to the size of the Bondi accretion radius. This can be up to $\sim$ 50 pc in typical cases (DiMateo et al. 2003), implying only slow UV variability.

In the case of NGC 1399, the RIAF models seem to have sufficient flexibility to fit the UV/optical spectral slope we observed for the NGC 1399 nucleus in 1999. However, the relatively short variability time scale ($\sim$ 1-5 years) in the UV/optical bands compared with the large Bondi radius of $\sim$ 35 pc (Loewenstein et al. 2001) appears to be incompatible with RIAF models. Similarly, the luminosity of the source is a difficulty for RIAF models. Loewenstein et al. (2001) found that the X-ray upper limit for NGC 1399 is not consistent with simple RIAF models given the estimated accretion rate, being over 100$\times$ lower than predicted. That would also be true of the UV and optical luminosities given in Table 1. The models predict relatively large ratios of X-ray to UV luminosity in λL_λ units, which are not supported by the values quoted above. Unfortunately, the UV and X-ray observations were not contemporaneous (they are separated by a year), so cannot serve as a good test of the X-ray/UV ratio.

For M87, DiMateo et al. (2003) argue that the famous relativistic jet may disrupt the RIAF inflow, suppressing radiation or yielding intermittent accretion (see also Fabbiano et al. 2003 for the case of IC1459). The jets themselves may carry off most of the accretion energy. The radio jets in NGC 1399 could well operate in a similar manner to suppress the accretion luminosity there.

There are, of course, other sources of fuel for AGN's than the surrounding diffuse gas. In their interpretation of the NGC 4552 event, Cappellari et al. (1999) favored a standard accretion disk model in which partial stripping of a single stellar atmosphere by the central SMBH (releasing $\sim 0.001 M_\odot$) was responsible for a flare-like energy release. Now that a twin event has been detected in NGC 1399, the likelihood of such stripping episodes should be quantitatively assessed to determine whether this is still a viable explanation. Although the tidal destruction of an entire star is a very rare occurrence (once every 10^4-10^5 years, Rees 1990 and Magorrian & Tremaine 1999), partial stripping could be more common. There is some evidence for strong X-ray flares consistent with tidal disruption events in a small number of galaxies from the ROSAT surveys (e.g. Gezari et al. 2003). Other objects, e.g. planets, could also be the source of transient events.

HST monitoring of nuclei with deep exposures at short wavelengths is an excellent means of assessing LLAGN variability and probing fueling mechanisms. Very small levels of mass transfer in the nuclei can be detected. As noted above, X-ray detection in such situations can be limited by stellar sources within the galaxy. Neither NGC 1399 nor 4552 were actually optimal cases for UV point source detections because of their abnormally bright FUV stellar backgrounds. This should be easier in galaxies with more normal UV colors, $m_\lambda(\mathrm{FUV}) - V \gtrsim 3$. There are several other instances of optical-band identifications with HST of nuclear point sources in gE galaxies, including NGC 4278 (Carollo et al. 1997), IC 1459 (Fabbiano et al. 2003), and NGC 4374 (Bower et al. 2000) that would be good candidates for HST monitoring.

After we submitted this paper, Maoz et al. (2005) reported results from an HST/ACS "snapshot" survey that confirms the value of high spatial resolution UV monitoring. They observed a sample of known UV-bright LINERS in spiral and E galaxies at 2500 Å at irregular intervals over 12 months. Most of the sources exhibit low-level variability, and some with earlier observations show fractional changes comparable to those of NGC 1399. The survey demonstrates that AGN's are indeed associated with many LINERS. All the sample sources with detected radio cores (as in NGC 1399) have variable UV nuclei. Of the new identifications, only NGC 4258 has a nuclear luminosity comparable to or fainter than NGC 1399 or 4552.

6. Conclusion

We detected a nuclear transient in the giant elliptical galaxy NGC 1399 on deep far-UV spectra taken with HST/STIS in January 1999. The source reached a maximum observed far-UV luminosity of $\sim 1.2 \times 10^{39}$ ergs s^{-1} at that time. Re-reduction of earlier HST archival

images showed that the source was detectable in an optical-band image in 1996 but not in UV/optical images from 1991 or 1993. It faded by a factor of $\sim 4\times$ by mid-2000. We cannot determine the duty cycle of the source.

Ordinary stellar phenomena are not likely explanations of such events. Instead, the activity is almost certainly associated with the low luminosity AGN responsible for the core/jet radio emission in NGC 1399. The source is much fainter than expected from its Bondi accretion rate (estimated from *Chandra* high resolution X-ray images), even in the context of "radiatively inefficient accretion flow" models, and its variability also appears inconsistent with such models.

NGC 1399 is of special interest because of its involvement with a nearby cluster cooling flow (Rangarajan et al. 1995) and the growing realization that AGN feedback probably plays a central role in regulating gas accretion and therefore galaxy and SMBH growth in clusters and in the early universe (e.g. Wu, Fabian, & Nulsen 2000; McNamara et al. 2005).

The properties of the NGC 1399 outburst are remarkably similar to the UV-bright nuclear transient discovered earlier with HST/FOC in NGC 4552 by Renzini et al. (1995). There had been no earlier evidence for activity at optical through X-ray wavelengths in either galaxy.

These accidental discoveries and the more recent detection of UV variability in known LINERS by Maoz et al. (2005) demonstrate that high resolution UV monitoring is a valuable means to study activity in nearby LLAGNs. Note that *Chandra* was able to place only an upper limit to the X-ray emission from the NGC 1399 nucleus, partly because of the presence of many X-ray bright binaries. UV nuclear emission will often present a greater contrast with the background galaxy than will X-ray emission. Especially when coupled with radio core observations over long periods, UV monitoring will be a useful discriminant between models for fueling activity in the vicinity of a supermassive black hole.

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Table 1. HST Observations of NGC 1399 Nuclear Source

Date	Instrument	Filter	$\bar{\lambda}$ (Å)	$f_{\lambda} \times 10^{18}$ (erg s^{-1} cm^{-2} Å^{-1})	λL_{λ} (erg s^{-1})
1991-11-07	WFPC1/PC	F555W	5429	< 3.5	$< 9.4 \times 10^{38}$
1993-10-05	FOC	F175W	1730	< 2.8	$< 2.4 \times 10^{38}$
1996-06-02	WFPC2/PC	F450W	4484	2.5 ± 0.5	5.5×10^{38}
1999-01-10	STIS	G430L	4480	6.4 ± 1.3	1.4×10^{39}
1999-01-10	STIS	G430L	5430	6.7 ± 2.2	1.8×10^{39}
1999-01-19	STIS	G140L	1525	16.0 ± 4.0	1.2×10^{39}
2000-05-18	WFPC2/PC	F606W	5860	< 1.5	$< 4.3 \times 10^{38}$

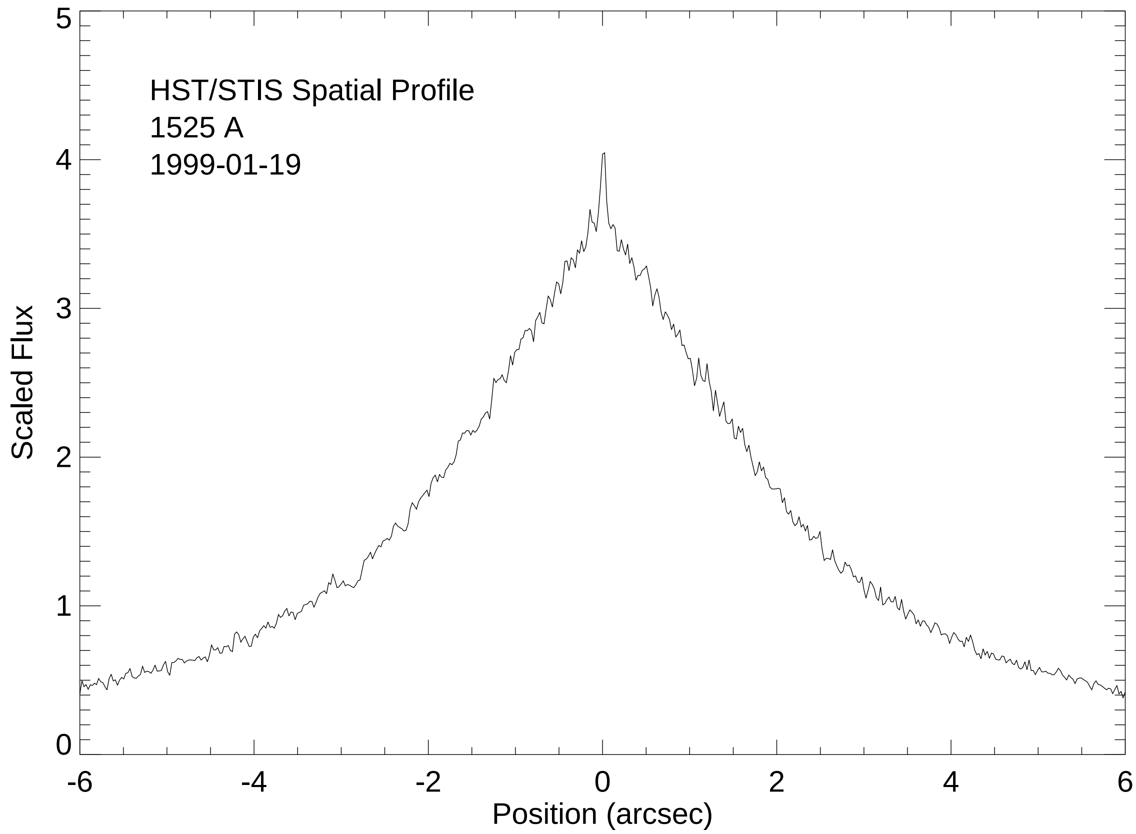

Fig. 1.— The spatial profile of UV light in the center of NGC 1399 from the STIS/FUV spectrum of January 1999. Plotted is the mean surface brightness per pixel (arbitrary flux units) for 0.024″ high bins within the 2″ wide spectrograph slit as a function of distance along the slit from the galaxy's light centroid. The profile is an average of the spectral image covering 1340-1710 Å. There is a distinct nuclear point source superposed on the broader profile of background stellar light.

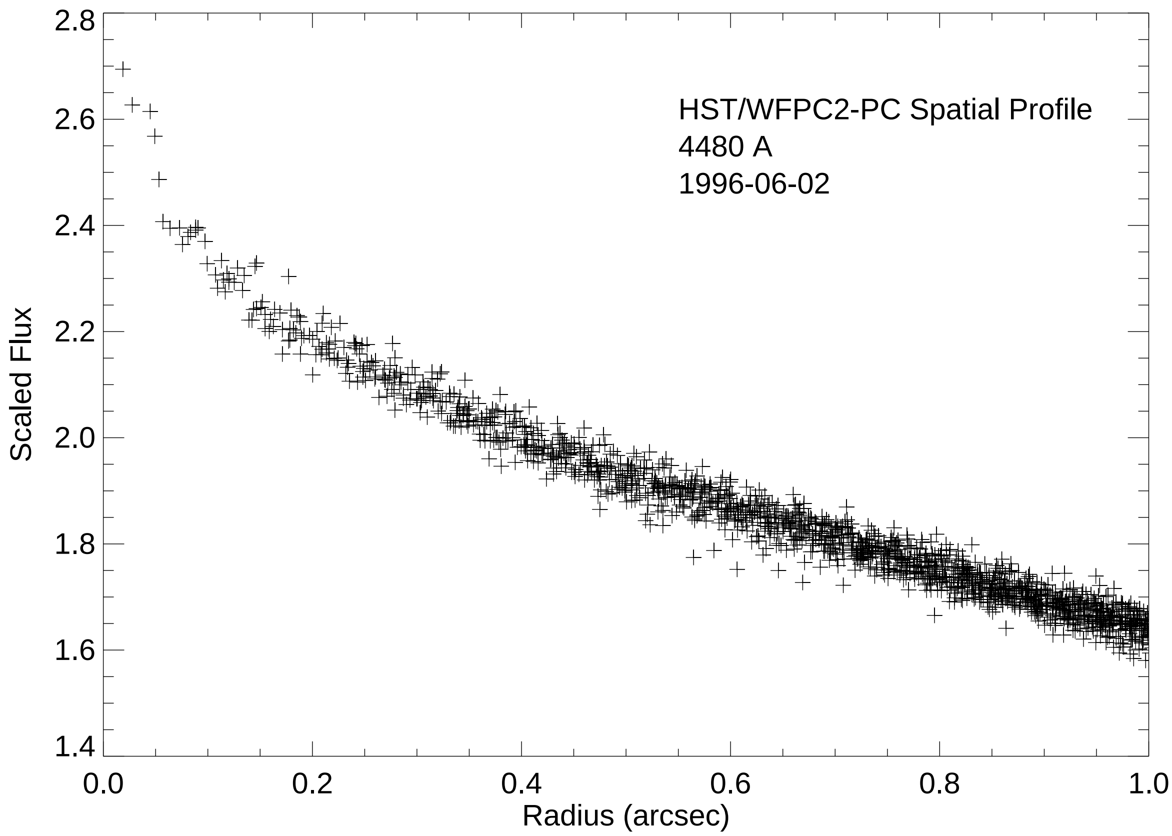

Fig. 2.— Central light distribution of NGC 1399 in the WFPC2-PC F450W image of June 1996. Plotted are the fluxes for individual pixels as a function of distance from the light centroid. The unit for the flux scale is 1.0×10^{-18} erg s^{-1} cm^{-2} Å^{-1}. The pixel size is $0.045''$. Although the stellar background light rises toward the center, there is a distinct nuclear point source superposed on it.